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Renewable energy's impact on rural development in northwestern Romania

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ABSTRACT

Romania has increased its production of electricity from renewable sources by relying on projects situated in rural areas. This paper explores the impact of renewable energy projects on rural development in northwestern Romania. The critical review of the literature has revealed that most studies stress the positive effects renewable energy projects can have on employment, demographics, revenues to the local budgets, and agriculture in the host communities.

We observed, however, that none of those studies had a quantitative approach and they do not study in a comparative manner these effects. This paper takes a step further and compares the evolution of the four variables for villages with and without implemented renewable energy projects. We compared the evolution of employment, demographics, revenues and processed agriculture land from 2010 to 2014. For the two groups of villages, the data shows no difference between villages with and without implemented renewable energy projects.

Introduction

Between 2009 and 2013, the share of renewable energy sources (RES) in the EU's energy generation mix increased from 9 to 16% and it is expected to grow up to 20% by 2020 (Eurostat Newsletter, 2016). This has brought about important changes in both the energy industry and public policy. The fast development of renewables put a lot of pressure on the energy system and requires new technical solutions to integrate renewable energy generation into the existing infrastructure. Because of these challenges, more and more authors discuss the impact renewables have on energy systems, price formation, and on the security of supply (Bolton and Foxon, 2014; Destouni and Frank, 2010; Goldthau, 2014; Markard, 2011). Others are concerned with the ecological impact of REP (Dincer, 2000; Quaschning, 2005). A smaller number of studies are separately addressing some of the changes that REP are producing in the economic and social landscape of local communities (ADAS Consulting, 2003; del Rio and Burguillo, 2008; Emmanouilides and Sgouromalli, 2013; Kammen et al., 2004).

From all the studies that analyze the link between socio-economic development and renewable energy projects (REP), we were interested in those that discuss the effects that renewable energy projects can have on the villages they are located in. Most papers that discuss the relationship between renewables and rural communities rely either on case-study research, or they look at national and regional data to make generalizations. On both these levels, scholars have found that renewable energy projects can have a positive impact on rural development in terms of employment, income, electricity prices, social capital, business opportunities, innovation or demographics. While certainly interesting and valuable, these papers have major drawbacks as they lack comparability and better contextualized understanding.

Looking only at the national or regional data on development does not tell us whether rural communities are profiting from the REPs. Also, focusing only on a few communities with implemented REPs does not tell us whether they are performing better than similar communities without such investments. But, how can we be sure that the development level is linked to the renewable energy projects at all? Would it be possible that renewable energy projects and rural development are only co-variating and in fact are dependent on a third, independent variable? Having these reasonable doubts in our mind, this paper wants to assess what is the impact that renewable energy project can have on the development of communities they are located in.

We take a step back and question the potential impact of renewable energy projects on rural development in terms of employment, revenues to the local budget, demographics and agriculture development. Relying on a large-N, quasi-experimental research design we observe the impact renewable energy projects can have on rural development

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by comparing villages that implemented renewable energy projects with villages that did not implement such projects. Since we cannot assume that solar, wind, hydro or biomass units produce the same effects on rural development, we will investigate the impact of each type of REPs on the economic and social well-being of local communities.

Our research focuses on the case of Romania. Between 2010 and 2014, the quantity of electricity generated from renewable energy sources[1] in Romania has increased tenfold. The increased share of renewables is the result of a development support scheme deployed by the Romanian Government in order to encourage the development of the REPs and comply with the Europe 2020 target goals set by the European Union. The fast development of this sector presented local authorities with promising new opportunities, but their results have not been properly assessed so far. Data from Transelectrica (the national electricity transport operator in Romania) indicate that the development of REP happened after 2010. Therefore, this paper uses 2010 as a starting point for assessing the impact of REP on employment, revenues to the local budget, demographics and agriculture development. Drawing on the findings of previous case studies, this research focuses on a smaller number of variables but compares a larger number of cases.

To answer the research question, this paper is structured along the following points:

1. Renewable energy and rural development - a critical review. This section discusses the existing literature and the link between renewable energy and development. The goal of this review is to discuss the main findings of other authors and identify the main shortcomings of their research. Through this critical review we will also argue why we selected the above mentioned four variables and why those are perceived by different studies to be affected by the deployment of a REP.
2. Methodology. This section presents the main methodological structure discussing the population and the sampling method, the data sources we rely upon and the specific methods used to analyze the data.
3. Analysis. In the first part of this point we present the state of renewable energy projects and existing renewable energy potential in North-West Romania. Here we will also discuss, based on a series of descriptive statistics, the main characteristics of the researched samples. In the second part of this section we compare the groups with installed projects with those that have attested renewable energy potential on the main socio-economic indicators. The use of descriptive and inferential statistics lay the foundation to discuss the main research question through hypothesis testing.
4. Conclusions and discussion. This section presents some possible explanations for the results and further implications of our research.

Renewable energy and development – critical review

Employment and demographics

Probably one of the most discussed effects of renewable energy projects is its effect on employment. Considering that renewable energy projects are developed mostly in rural areas (Dulcinea Cuellar, 2009; OECD, 2012;) one would expect that the villages where those projects are developed are benefiting in terms of employment, revenues to the local budget, demographics and agriculture development.

According to Del Rio and Burguillo, renewable energy projects can have a significant employment creation and income generation during the construction phase. In the operating phase, the employment effects can vary depending on the type of renewable energy project (del Rio and Burguillo, 2008, 2009). A wind power project for example, can produce relatively modest employment effects. However, a biomass power plant project will have a stronger impact on local employment given the necessity of harvesting raw materials, transportation to the production facility, and other operations required by biomass power projects (del Rio and Burguillo, 2008).

OECD research also highlights the positive effects that renewable energy projects are producing, especially in rural areas (OECD, 2012). The research notes that “in a small rural community with less than 1000 inhabitants in Extremadura, for instance, a large-scale (50 MW) CSP installation employs up to 40 people on open-ended contracts,” (OECD, 2012). Further on, Kammen et al. argue that overall renewable energy projects have a positive effect on employment and that renewable energy generates higher employment per MW of produced energy than fossil fuel based energies (Kammen et al., 2004).

Probably the most emphasized example of positive impact on employment comes from Germany. The German Environmental Ministry reported that since 2004 the total number of green jobs increased by 55%, and by 2007 more than 250,000 people were working in the sector (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2009). Along the same lines, Buchan argues that the German case is a good example of the job creating potential of renewable energy projects. Buchan stresses also that if the German state would be able to keep the same positive employment dynamics while decreasing the direct subsidies to renewables, then REPs could become a viable long-term solution to unemployment (Buchan, 2012).

It is important to highlight however that most studies mentioned earlier do not measure employment effects throughout time linking those with the local community as well. We believe however that we cannot discuss about real effects on employment if those effects are not persistent throughout time, meaning an increase level employment. If however the projects increase the employment for a limited period of time, during the construction phase, but cannot sustain this effect we believe it is rather an overstatement to discuss about job creation potential at the local level. In that specific case we can discuss of positive externalities connected with a specific stage of project's deployment, a stage which itself can be quite limited in time. In our understanding, long lasting impact on development of a community is directly connected to a permanent type of employment that has the potential to generate sustainable development within the community. While it certainly is a positive externality of some projects, temporary employment cannot be considered as a sustainable, positive effect of a renewable energy project.

Alongside the positive effects on employment, del Rio and Burguillo highlight the positive impact produced by REPs in three rural settlements in Spain. While none of the projects led to migratory in-flows to those villages, the REP contributed to “keeping of some people in the local territory” thus preventing emigration. (del Rio and Burguillo, 2009). Given the increasing general migration trends from rural to urban areas (Lang, 2010), keeping people in rural areas is can be considered a positive effect of REPs. By looking closely at the case of Navarre in Spain, Faulin et al. found positive effects on youth employment (Faulin et al., 2009). Based on those findings Faulin et al. suggest that for the case of Navarre the development of REPs had also a positive impact on the structure of the population by employing more young people, thus preventing the aging of the local population (Faulin et al., 2009).

While they differ in type of argument and geographical area, all of the studies mentioned above agree on the positive effect that renewable energy projects can have on employment. Whereas less discussed, the positive effect on demographics is also connected with the development of renewable energy projects.

We believe however that there is an important aspect neglected by these studies. Specifically, none of the researches looked at employment and demographic dynamics in villages without REPs. In order to observe the real impact a project can have in a specific rural community we have to compare communities that host REPs with similar communities that

[1] Romania has a big part of electricity generation coming from hydro-power plants. Even though hydro generation is considered renewable energy sources, according to Romanian legislation only hydro-power plants with a maximum installed capacity of 10 MW can be entitled to renewable energy support scheme. In this context, renewable energies in this paper will refer to all types of renewable energy sources, excluding hydro-power plants with an installed capacity bigger than 10 MW unless otherwise stated.

do not host a REP. If there is no difference between the two groups we have to reconsider the general argument that renewable energy projects alone can have any effect on employment or demographics.

Revenues to the local budget and impact on the agriculture

Implementing renewable energy projects can have a positive effect on the financial wellbeing of a community. One can distinguish two types of financial effects produced by a renewable energy project: public and private financial gains.

OECD (2012) and ADAS consulting (2003) studies argue that renewable energy projects can produce important revenues for local budgets and public financial gains, through taxation. Once a project is developed in a specific location, the investor has to pay a part of taxes and levies to the local budget (e.g. land tax, income tax, etc.). Moreover, one of the possible direct financial gains for the local communities comes from renting public lands to a renewable energy investor. In the case of a wind farm or a photovoltaic (PV) solar power plant, the investor needs a large area for deployment, thus if the local authority has the land and is willing to rent or sell it then it might become a good source of revenues for this community (del Rio and Burguillo, 2008; Hanley and Nevin, 1999; OECD, 2012). Private revenues resulting from the implementation of a REP can be more diversified, from renting land for the deployment of a project, to selling agriculture waste for biomass production by local companies (Destouni and Frank, 2010; Dulcinea Cuellar, 2009).

Dulcinea Cuellar (2009) argues that biomass power production can have a positive impact on agriculture as well. As presented by Cuellar, the biomass power plant is dependent upon a primary material for the power production, a material which is often linked with agricultural activity. Farmers could sell their agricultural waste or producing crops for biomass power plants. This could have a positive impact on the development of agriculture and will ensure higher revenues for the farmers (Dulcinea Cuellar, 2009). Given the possible higher revenues from agriculture, farmers will exploit all their land and will increase the proportion of exploited agriculture land (IRENA, 2012).

The same as for the employment and demographic effects, the impact on agriculture and revenues is presented either through a case study analysis or through an aggregated analysis of all the REPs at the national/regional level. In this context, it is really difficult to assess the opportunity cost of those developments. A comparative analysis is necessary in order to understand whether a REP is really generating mentioned positive effects.

None of the existing studies are looking at the relationship between the size of the community and the size of the project. We cannot expect a project with an installed capacity of 0.1 megawatt (MW) to have the same impact on local development as a project of 100 MW. Consequently, we cannot expect a village of 3000 inhabitants to benefit from an REP as much as village of 700 inhabitants. To account for this variable, we designed a new unit of measurement which observes the renewable energy installed capacity in kilowatt (kW) per inhabitant. In our analysis, we will present the size of the renewable energy project not in terms of installed MWs, but in terms of installed kW/capita. Because we are looking at the relationship between projects and communities, we have to be sensitive regarding the specific characteristics of both elements.

Methodology

Case selection

Since 2010, Romania had an impressive increase of electricity generated from renewable energy sources. Since the development of REP did not occur uniformly throughout Romania we focused on the North-West Development region of Romania.[2] Out of eight development regions in Romania, as we can see in Fig. 1 the North-West region leads in the number of implemented renewable energy projects based on hydro, solar and biomass resources. Also from Fig. 1 we can see that North-West region has low share of implemented wind power projects (around 3% of total implemented wind power projects are located in that region).

However, if we pay close attention to the graph, we will see that for the wind power projects, the graph is clearly skewed in favor of South-Eastern development region. The majority (78%) of national wind projects are implemented there, but the region does not lead in any other type of other renewable energy projects. The low share of wind power projects for the North-Western region is balanced by the biggest share in other renewable energy projects, as well as the clear wind power potential in the region that could be exploited in the future.

The number of overall projects gives us an understanding on how many project are deployed in one region, but because projects can have different sizes, it is still important to see how many independent initiatives exist within each region. Since every project is deployed in a given locality we were able to select a larger number of cases to include in our analysis. This does not mean however that we should exclude the size variable from our analysis. Thus, by looking at the size of the deployed projects we connected it with the population, as suggested earlier and built the kW/capita index for all the researched regions. In this way we were able to take in account the size of the project as well as the size of the region.

As shown in Fig. 2, the proportion of installed kW per capita follows the same pattern as the proportion of deployed projects. The only clear difference is that the North-West region is not leading in installed capacity of solar power plants per capita as it did at the number of the projects. Nevertheless, it still holds an important share of solar power installed capacity, being the third region after South (22%) and South-West (34%). However it continues to lead in hydro power and biomass power installed capacity. The change for the installed solar power projects comes from the fact that the South and South-West regions have fewer projects with a much higher installed capacity. For the case of the North-West region we have larger number of projects with a smaller installed capacity, which also fits into the scope of our research because we would like to have a larger diversity of communities with implemented projects with varying installed capacities, which is the case for the North-West region.

The North West region therefore has a uniform distribution of renewable energy projects as well as installed capacity. We can say that, from all regions in Romania, only the North-West region has a large number of projects and relatively high proportion of installed capacity per capita on all types of renewable energies. For these reasons, the region offers an ideal foundation for our study, with transferability potential to other regions.

Population and sampling

The North-West region comprises 403 townships with a total of 1800 villages[3] that reunite approximately 90% of the surface and only 45% of the total population of the region. Within the region villages are characterized by some common trends: declining population and emigration, availability of natural resources and high renewable energy potential, low revenues to local budgets, and a high share of informal employment in agriculture and forestry (Cristea, 2013).

From the North-West region we selected all localities with a functional renewable energy project. The analysis focuses on hydro, wind, solar and biomass renewable energy projects, therefore we organized villages into four groups based on the type of the renewable energy projects. Projects based in urban centers and solar projects with an installed

[2] North-West development region, according to the existing legislation, is composed of the Bihor, Bistrita-Nasaud, Cluj, Maramures, Satu Mare and Salaj counties.

[3] According to the existing administrative division, townships can reunite several villages and are the smallest administrative unit under the current legislation. For the sake of simplicity, further on in this paper, discussing about villages or communities we refer to townships as the administrative unit unless otherwise stated.

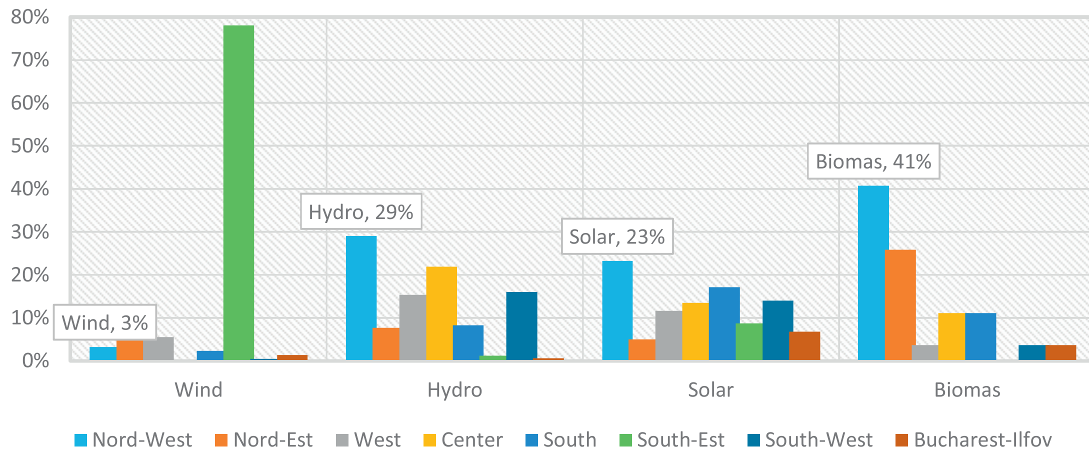

Fig. 1. Proportion of all implemented renewable energy projects by each development region (Transelectrica, 2015).

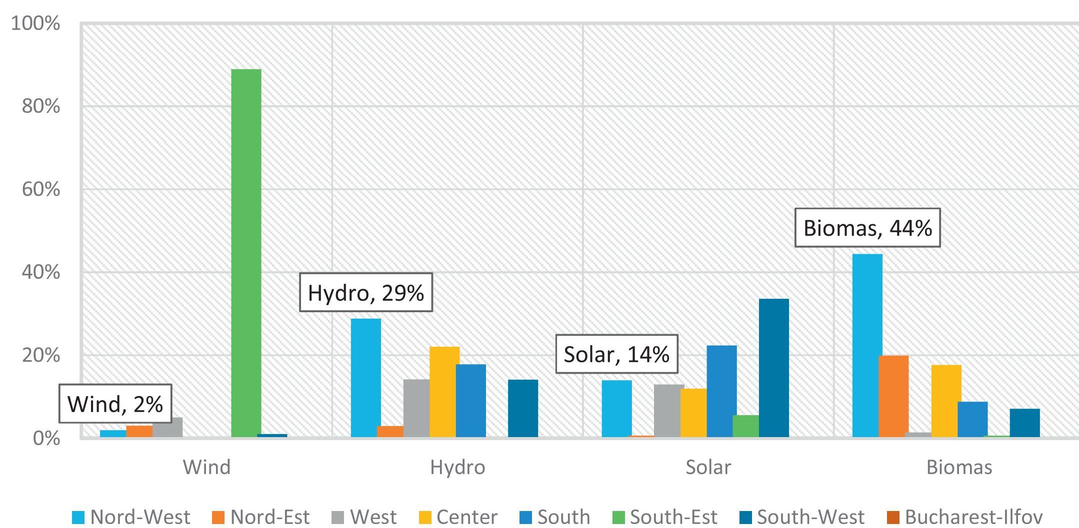

Fig. 2. Proportion of installed capacity (kW) per capita by each development region (Transelectrica, 2015).

capacity lower than 0.5 MW, were excluded from the analysis. Installed capacities lower than 0.5 MW are often on-site installations of enterprises or households, therefore their primary goal is not the production of electricity for commercial purpose but for personal use. While some are certainly relevant and interesting to study, we decided to focus instead on projects aiming to produce and sell electricity. In the region there are 2 villages with implemented biomass projects, 5 with wind power generation, 25 localities with micro-hydro power projects and 55 localities with operating solar power projects, all these projects being deployed after 2010 (Transelectrica, 2015). Out of 87 REP deployed in North-West region, 85 are owned by private investors while two belong to the local authorities (Transelectrica, 2015).

A control group of villages was selected on the availability of renewable energy potential. For wind power production we selected localities which have an average recorded wind speed of 6 m/s or higher, while for solar – the localities with the irradiation index higher than 1250 kWh/m^2/year were considered. Villages with hydro potential we selected based on dummy variable, therefore only the villages which have attested potential for building a micro-hydro power plant were included. Communities with a biomass potential higher than 7 Tera joule per year (TJ/year) have been considered for the biomass group. After applying these criteria, we have selected 181 villages with attested solar potential, 67 with hydro, 33 with wind and 146 with biomass potential.

Data

For the data on the implemented REPs we relied on the information from Transelectrica (2015) on installed capacity and the place where the project is deployed. Transelectica collects all the data regarding the size of the REPs, location, year of operation and ownership.[4] This data constitutes the initial foundation of the empirical evidence for our research since it offered the possibility not only to map all the existing projects but also to build the kW/capita indicator of installed capacity. Linking a specific project with the township where it is deployed we were able therefore to build the index for the locality and further on expand this index for the development region.

In order to build the renewable energy potential index for the selected regions we used several different sources: the National Authority for Meteorology for data on solar and wind, ICPE (Institutul de Cercetari Electrotehnice) for data on solar, INL for data on biomass, and Hidroelectrica for data on hydro. These sectorial analyses are included in the Evaluation Study of the Current Potential of the Renewable Energy Sources, elaborated by the Ministry of Economy in 2008 (Ministerul Economiei, 2008).

[4] This data is publicly available and can be accessed through Transelectrica's website.

However, this study has mapped only the different renewable energy resources at the national level. In this context, taking into account the different types of map formats, we had to geo-reference the maps first and then create the Geographic Information System (GIS) database for each type of REP by digitizing the maps. The next step was to allocate to each territorial administrative unit a value for every type of RES. Thusly, we improved the initial data presented in the study from the Ministry of Economy by allocating renewable energy potential indicators up to the smallest territorial administrative unit. By doing so, we were able to discuss and compare renewable energy potential not only at the regional or zonal levels, but also at the level of villages and communities. The GIS database and the spatial analysis were done with ArcGIS 10.1 software.

We compared the two groups of villages based on three variables: employment, revenues to the local budget and demographic dynamics. For the project based on biomass we included a fourth variable – the proportion of the agriculture land processed. This variable is relevant for the present research since it was suggested by earlier studies that biomass energy project can foster the development of agriculture in the region (IRENA, 2012). The data sources for these variables were the National Institute for Statistics (for demographic and employment items), respectively, and the Ministry of Regional Development and Public Administration (for the local budgets and proportion of agriculture land processed).

Methods

To answer the research questions, this study relies on a quasi-experimental logic in which we have no control over the stimulus and the two samples were independently selected. In our case the stimulus is the deployment of the renewable energy project. We use a nonequivalent control group design, matching the group of villages with installed REP with the villages without REP on specific type of renewable energy potential. It is important to highlight that the main goal of our inquiry is to observe whether the deployment of such a project had any impact on the host community if we compare those communities with similar cases from across the region without a deployed REP.

First, we look closely into the characteristics of the villages with implemented renewable energy projects. We focus on descriptive statistics to present the distribution of installed capacity of renewable energy per inhabitant. Introducing this indicator we control for the size of the host community when discussing about renewable energy projects' impact on those communities. We also rely on descriptive statistics to present the socio-economic characteristics of both compared groups.

Since the explanatory variables are all parametric we rely on a parametric method to test the effect of the stimulus. For this task we used Welch's two-sample *t*-test given its robustness to different sample sizes and unequal variances (Kohr and Games, 1974). The two sample *t*-test allows us to analyze the difference between the two samples (with and without REP) even though we do not know the standard deviations of the general population. Thus we can test whether two independently selected samples have statistically significant differences on any of the researched variables.

For the case of biomass and wind power production we calculated the z-score for each villages with implemented REP based on the general sample of villages with attested wind or biomass potential. We choose to use this method due to small numbers of villages with implemented projects (3 on biomass and 5 on wind) and consistent differences in the installed capacity per capita between the researched cases. The z-score measures how many standard deviations from the group/sample mean a given score is. In our case, using the z-score allows to observe whether the values of any of the 8 cases on the researched variables are significantly different compared to the general characteristics of the sample.

Localities are compared on the variance of each of the above-described variables (employment, local budget revenues, demographics and the surface of agriculture land for biomass). In practical terms we compare the villages on the difference between the values of employment, demographics, registered revenues to the local budget and proportion of processed agriculture land recorded at the beginning of 2010 to values recorded in 2014 after a series of REPs were deployed in certain localities. The study aims to determine whether there is a different variance in the observed variables across the two researched groups of communities, thus answering the question whether villages that host implemented REPs have a competitive advantage compared to similar villages that do not host implemented projects.

Analysis

The analysis part is divided into two separate sections. First, we review the different types of renewable energy potential and implemented projects presenting also the main descriptive statistics for the researched groups for 2014. Second, we analyze the impact renewable energy projects produce in the localities they are deployed in by

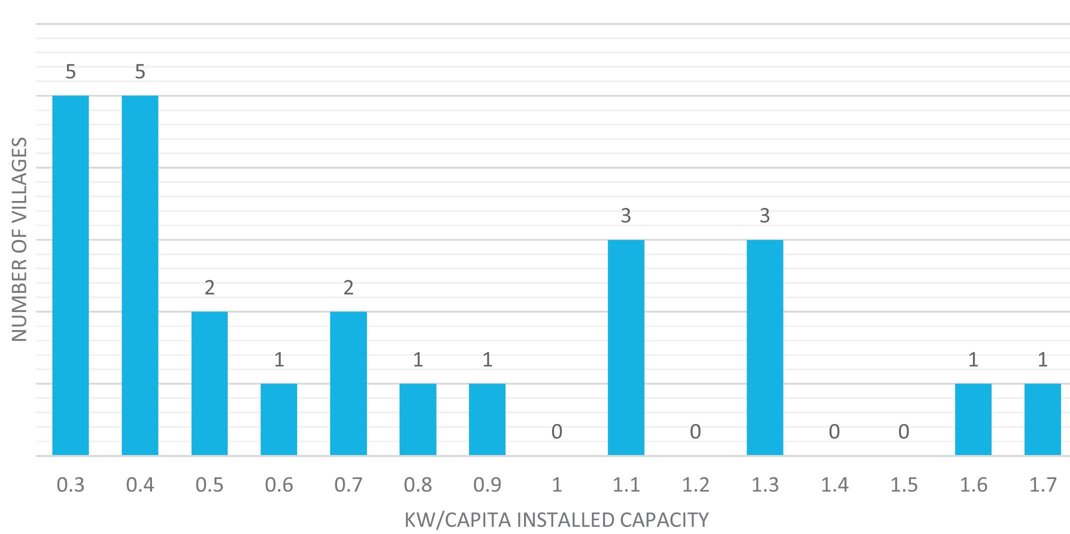

Fig. 3. Distribution of solar installed capacities (kW) per person.

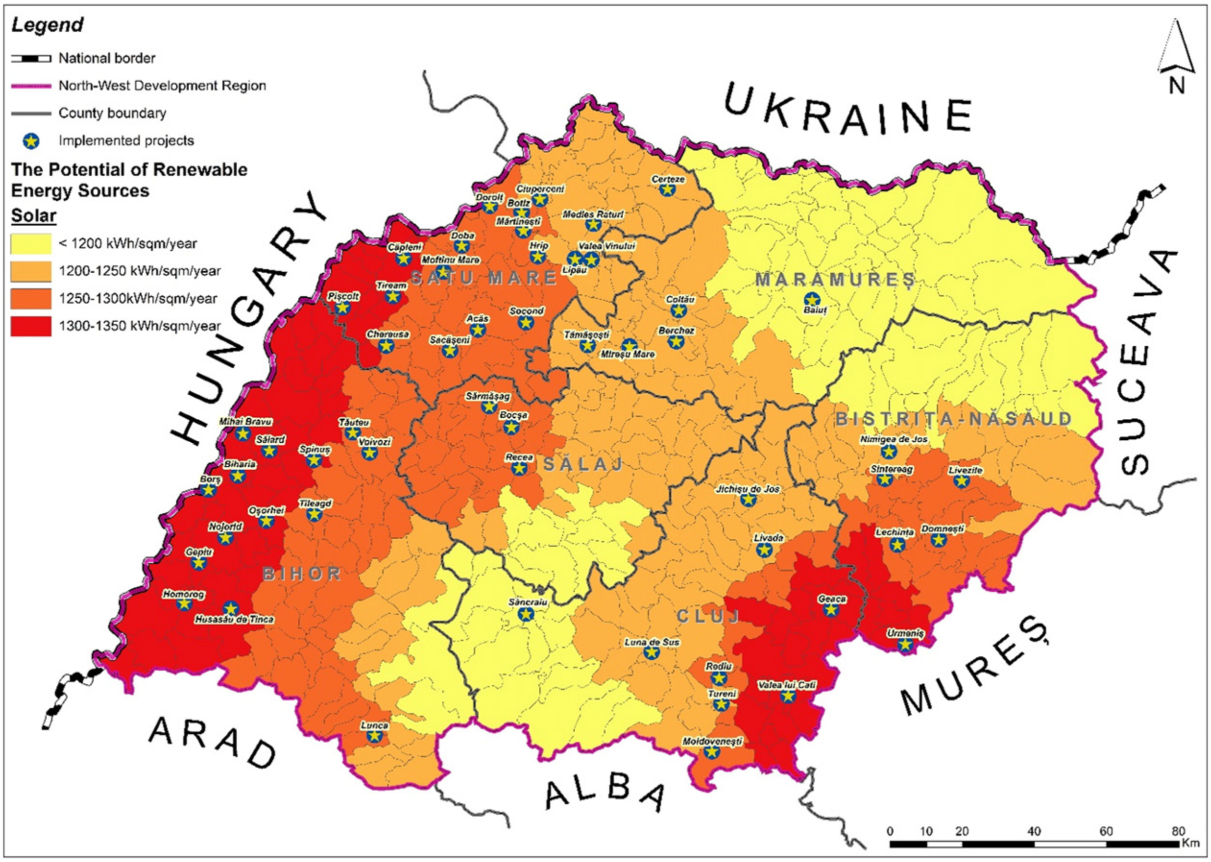

Fig. 4. Solar energy potential and implemented projects in North-Western Romania.

applying inferential statistics. Three hypotheses are tested for villages with solar, hydro and wind power plants, and four hypotheses for the localities with biomass power plants:

H1. Villages with installed renewable energy projects (hydro, solar, wind and biomass) have a better employment dynamic than villages without REPs.

H2. Villages with installed renewable energy projects (hydro, solar, wind and biomass) have a better demographic dynamic rate than villages without REPs.

H3. Villages with installed renewable energy projects (hydro, solar, wind and biomass) have higher incomes to the local budgets than villages without REPs.

H4. Villages with installed biomass projects have a larger share of exploited agricultural lands than villages without implemented biomass power plants.

Renewable energy potential and implemented projects in North-Western Romania

Solar

In the North-West region there are 55 villages where one or more solar power projects with more than 0.5 MW installed capacity are implemented. Fig. 3 shows that the biggest part of localities with REP has an installed capacity ranging from 0.5 to 1.5 kW/capita. The second cluster has an installed capacity bigger than 1.75 kW/capita. We will

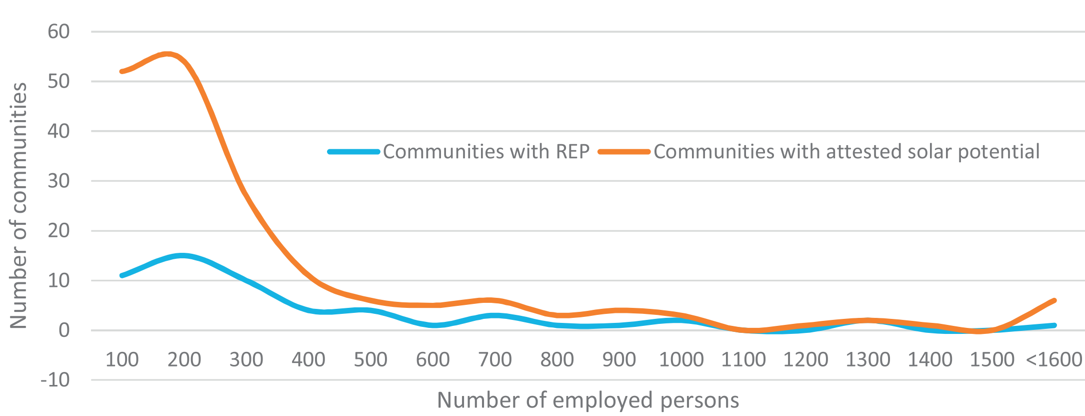

Fig. 5. Employment in communities with installed solar projects and with attested solar power potential, North-West Romania, 2014.

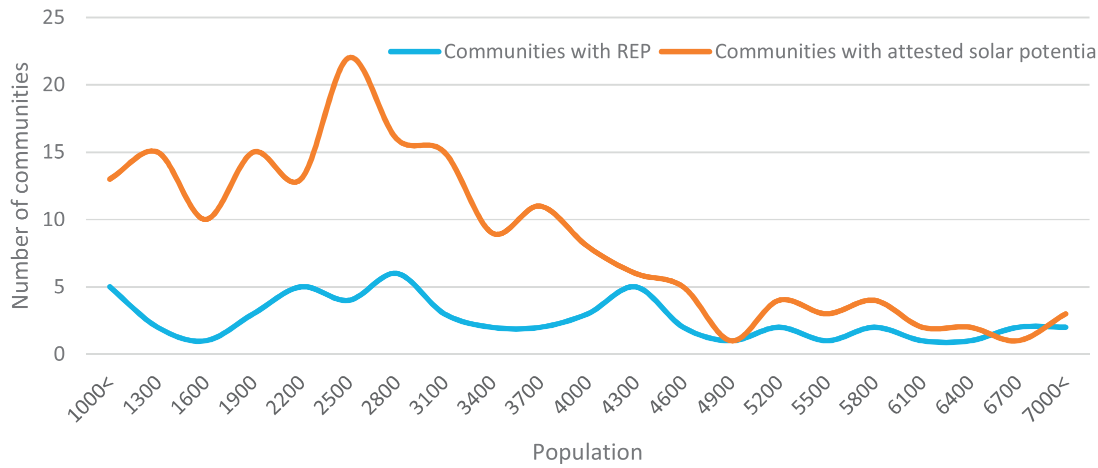

Fig. 6. Population in communities with installed solar project and with attested solar power potential, North-West Romania, 2014.

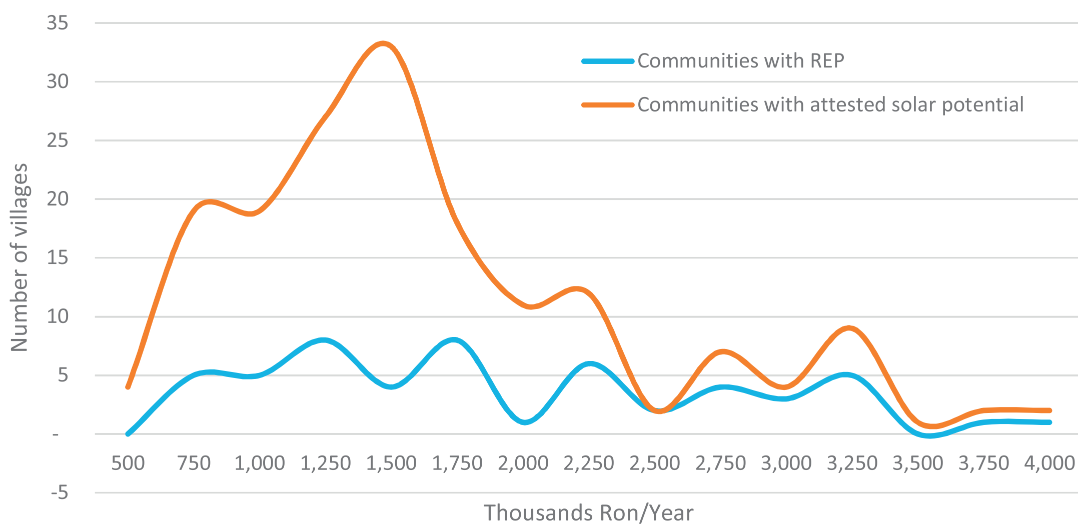

Fig. 7. Revenues to the local budget in communities with installed solar project and with attested solar power potential, North-West Romania, 2014.

consider this grouping when comparing villages with installed renewable energy projects with villages without. Fig. 4 shows the distribution of solar irradiation across the researched area detailed down to the township level. Also, in the same figure, we marked with a start the working solar power projects.

Based on Fig. 4 we can argue that a majority of projects are located in areas with solar irradiation of 1250 kWh/m^2/year or higher. However, there are a few projects implemented in areas with solar irradiation varying from 1200 to 1250 kWh/m^2/year. Only 2 projects out of 55 are deployed in areas with solar irradiation lower than 1200 kWh/m^2/year.

The analysis compares the villages with implemented projects (the one marked with the star in Fig. 3) to the villages with attested solar irradiation of 1250 kWh/m^2/year or higher.

Looking at the general socio-demographical indicators for the two groups for the 2014 we see that overall both samples display similar distributions on all the researched variables. It is important to highlight that Figs. 5, 6 and 7 represent the general characteristics of the two samples. The charts below aim to simply describe the main characteristics of the two samples without comparing them. This representation is important in order to have an understanding of the general profile of the researched groups. Based on this data we can say that an average village with an installed REP has around 3600 inhabitants, with 372 employed people registered and 1.9 million RON[5] incomes to the local budget. On the other hand an average village without a deployed REP but with an attested solar power potential will have around 3200 inhabitants, with 319 employed and 1.8 million RON revenues to the local budget.

This similar distribution of values on the researched variables for 2014 does not mean however that we can argue for the absence of any effect of the deployment of the project. It may well be that the villages with the deployed project had a worse score in 2009 on the researched variables, thus the deployment of the project could have improved the situation. A hypothesis which we will test further on in our study.

Hydro

The Romanian government distinguishes between hydro and micro-hydro power plants. The former, according to Legea 220 din 27/10/2008 (2008), has a maximum installed capacity of 10 MW. Hydro-power plants with higher installed capacities, while still considered renewable energy sources, are not entitled to state support. This analysis focuses on micro-hydro power plants as those are the ones encouraged by subsidies.

[5] RON – Romanian Leu, national currency in Romania (approximate exchange rate 1 EUR = 4.5 RON).

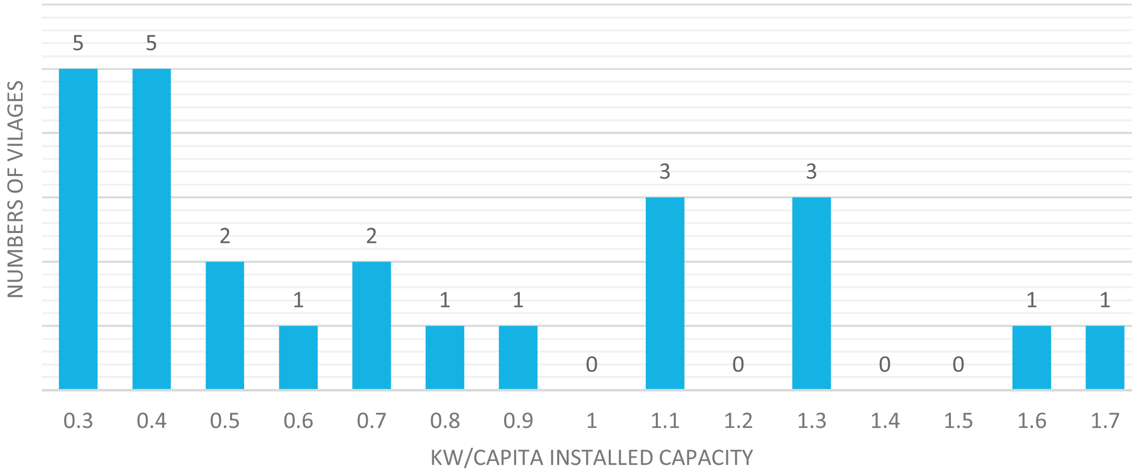

Fig. 8. Distribution of hydro installed capacities (kW) per person.

In the North-West region there are 25 villages that have installed micro-hydro generation projects (Transelectrica, 2015). Fig. 8 shows the distribution of localities on the installed capacity per capita range. In order to account for the differences in the installed capacity per capita we will divide the 25 villages in two sub-groups, the first one with installed capacity lower than 0.9 kW/capita and the second with an installed capacity higher than 1 kW/capita.

Compared to other types of RES, for hydro potential we had only a dummy variable which accounts for the presence or absence of the hydro potential (Fig. 9). Similarly to the case of solar, our analysis compares the villages with attested hydro potential with villages that have a running micro-hydro power plant (marked with a star).

It is worth highlighting that the North-West region is leading in the implementation of micro-hydro projects, mostly due to the region's specific geography. But the region also hosts bigger hydro projects, such as Tarnita-Lapusesti and Belis-Fantanele, which can provide both an incentive and expertise to the smaller projects.

Similar to localities with solar power projects, we can see from Figs. 10,11 and 12 that the groups with installed hydro power project and those with attested hydro power potential display similar distributions of values on the researched variables for 2014. An average community with an installed hydro power project would have 4300 inhabitants, 300 employed persons and 1.9 million RON income to the local budget. Villages without an installed project but with attested

Fig. 9. Hydro energy potential and implemented projects in North-Western Romania.

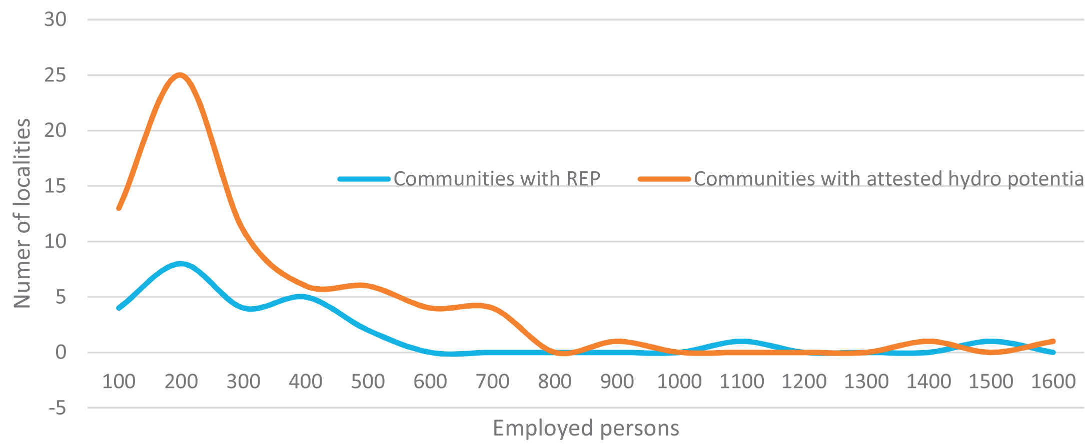

Fig. 10. Employment in communities with installed hydro power projects and with attested hydro power potential, North-West Romania, 2014.

hydro potential look quite similar with an average number of inhabitants of 4100, of which 400 employed and 2.4 million RON income to the local budget. The difference in average values from the two groups comes from different sample size and subsequent different distribution of the values on the three variables.

Wind

In North-Western Romania there are 5 villages with implemented wind power plants projects (Transelectrica, 2015). Out of the five projects, four have an installed capacity smaller than 0.2 kW/capita (0.18; 0.19; 0.04; 0.12) and one has an installed capacity of 2.42 kW/capita. We also identified 33 villages that have a recorded average wind speed of 6 m/s and higher, and can be considered for a possible development of a wind farm project (Fig. 13). We will therefore focus our comparison on those cases.

Given the small number of communities with deployed wind power projects Table 1 presents only the average value of population, employment and revenues for the villages with attested wind power potential. We also included in Table 1 the 6 cases with installed wind power project with the exact value on all 3 variables for 2014.

Based on the Table 1 we can see that, within the communities with deployed wind power projects, the average values of the researched variables are very diverse. However, if we compare them with the values for the average case of the non-REP group we can see that none of the cases would be located further than 2 standard deviations from the average value, meaning that in general terms we can say that the communities with the wind power projects deployed are not statistically different than the general sample of the ones with attested wind potential. Based on the presented data we can argue that an average village with wind power potential has 3400 inhabitants, with 290 employed and 1.9 million RON revenues to the local budget.

Biomass

With a total of 14 biomass projects, the North-West region is leading at national level because those projects represent 41% of the total biomass energy projects deployed and 44% of the total installed kW/capita per region at the national level. This data highlights two important things: first, the biomass energy projects are poorly developed in Romania. Considering that Romania has large agriculture and forestry sectors, which offer the primary material for biomass energy production (Dulcinea Cuellar, 2009), it is quite puzzling to see so few developed projects both at the regional and national levels. Second observation is that while biomass power projects are scarce, the North-West region is leading the implementation of those projects, so we could expect a further growth in the sector.

Currently, there are 14 biomass projects operating in North-Western Romania (Transelectrica, 2015). As we can see in Fig. 14, only 3 are in a rural area, while the remaining 11 are in urban centers.

All three projects are Combined Heat and Power (CHP) solid fuel based (biomass) plants aiming to produce electricity for the national power system as well as heat for the local public and private agents. The project deployed in Moftinu Mic is of rather small dimensions, having an installed capacity of only 0.9 MW, resulting in 0.79 kW/capita installed capacity. The CHP biomass power plant from

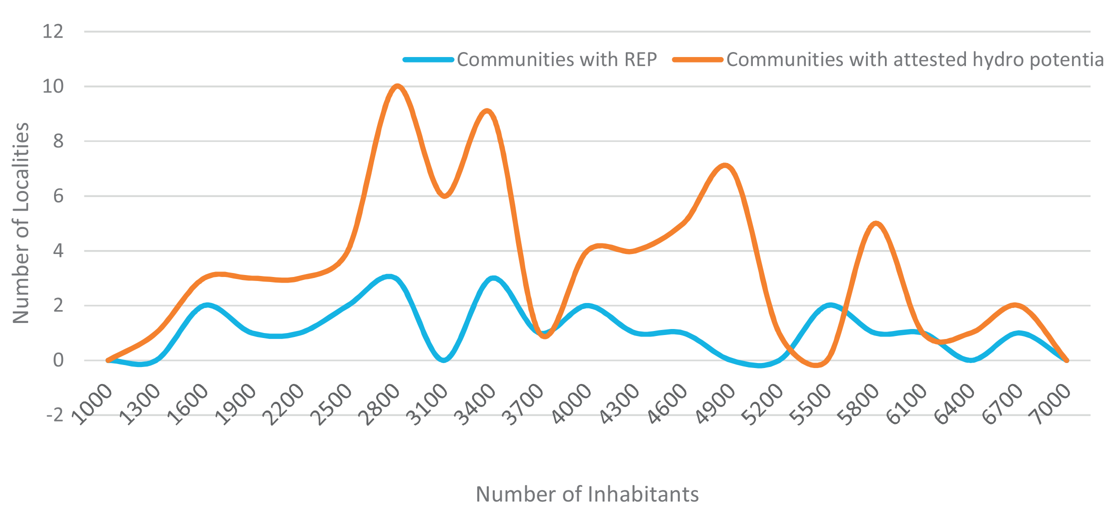

Fig. 11. Population in communities with installed hydro power projects and with attested hydro power potential, North-West Romania, 2014.

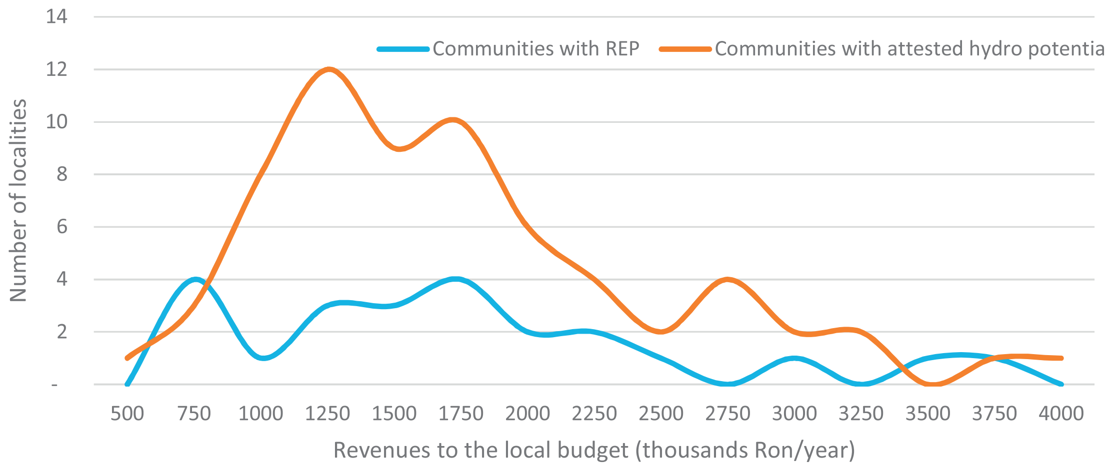

Fig. 12. Revenues to the local budget in communities with installed hydro power projects and with attested hydro power potential, North-West Romania, 2014.

Rascruci is on the other hand one of the biggest of that kind in Romania, having an installed capacity of 10 MW, resulting in 6.04 kW/capita installed capacity. The one from Cefa is in the middle with an installed capacity of 2.98 MW and 1.24 kW/capita installed capacity respectively.

The same as for the wind power projects, we can see that for the biomass, all three villages that have a deployed project are not statistically different from the sample of villages with attested biomass potential. While the cases are different between them, if we look at the average score for the general sample and consider also the standard deviation all of them will fit within two standard deviations from the mean on all of the researched variables (Table 2).

Overall, the North-West region is characterized by medium to high potential on all types of renewable energies. This region has the largest shares of deployed renewable energy projects in biomass, solar and hydro, but fewer wind energy projects. The analyzed data offers a solid ground to continue the comparative assessment of the renewables' impact on the rural development.

Renewable energy projects – impact assessment

Solar projects

In order to control for differences in the installed capacity per capita we divided our REP sample into two groups – the small installed solar

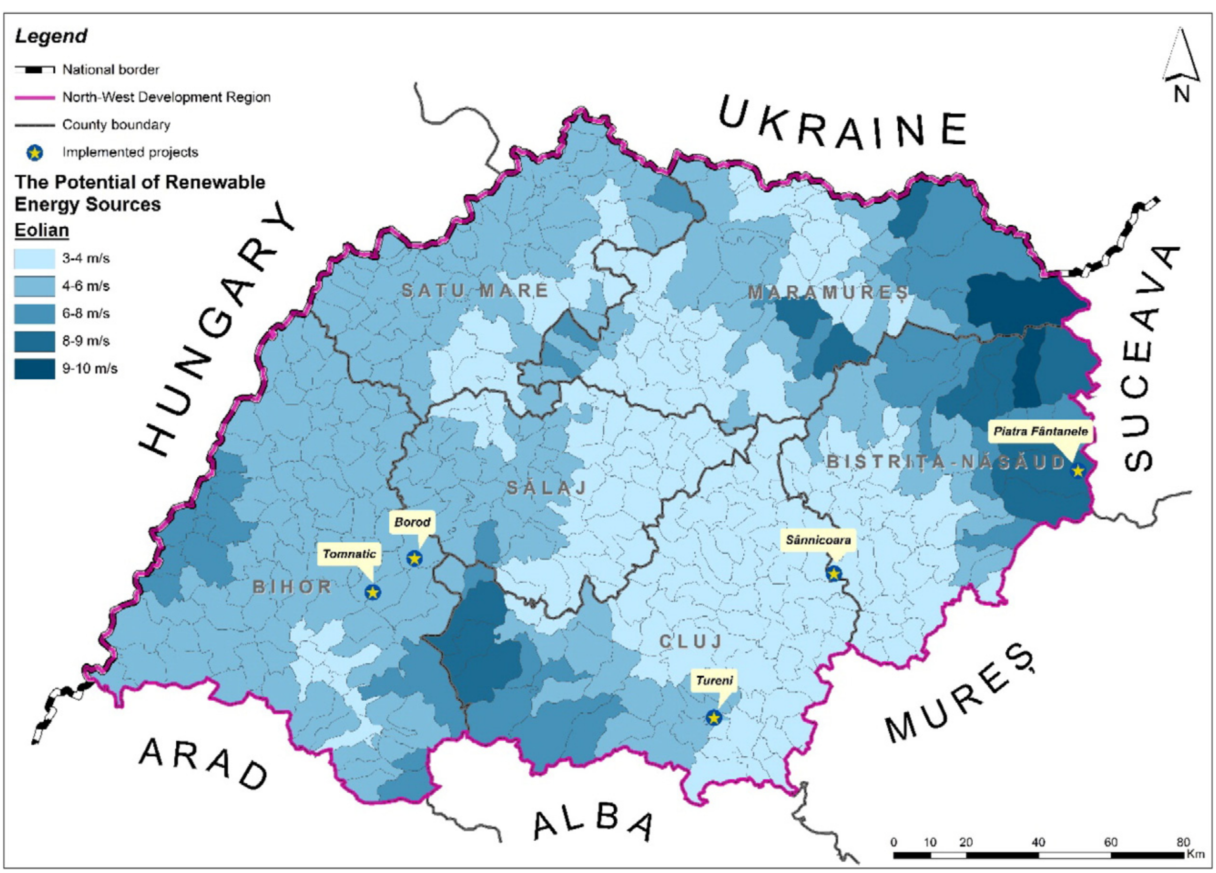

Fig. 13. Wind energy potential and implemented projects in North-Western Romania.

Table 1
Values of population, employment and revenues to the local budget for communities with installed wind power projects and with attest wind power potential, 2014.

Township	Population	Employment	Revenues to the local budget (million)
Average case (locality without REP but with attested wind potential)	3400 (st. deviation – 1970)	290 (st. deviation – 430)	1.9 (st. deviation – 1.1)
Piatra Fantanele	6651	364	2.8
Sanicoara	3061	90	0.7
Tureni	2238	193	2.7
Borod	2980	373	1.5
Tomnatic	4053	679	2.1

capacity per inhabitant (up to 1.5 kW/capita) and the big installed capacity of solar per inhabitant (higher than 1.75 kW/capita). We had to run therefore two separate two sample *t*-test (alpha level – 0.5) in order to test our hypotheses. Both groups had the skew < 2 and the kurtosis < 8 for all three variables, therefore the values can be considered normally distributed.

The first *t*-test compared the small installed capacity REP group (N = 39) with the villages without solar power projects (N = 181) on the variation of employment, revenues to the local budget and demographics for the period 2010–2014. The result of the *t*-test showed no statistically significant differences between the means of the two groups on any of the three variables. In order to test whether villages with a higher installed capacity behave differently we ran a second two-sample *t*-test which compared big installed capacity REP group (N = 16) with the villages without an installed project (N = 181). The same as for the previous case, the test showed no statistically significant difference between the means of the groups.

Contrary to our initial expectations and literature arguments, it seems that the existence of a solar power project does not have any impact on the employment, local revenues or demographic dynamics of a given community. Comparing the variation in these three variables for the two categories of villages we have observed no difference in the means of the groups. Moreover, even comparing only projects with higher installed capacity per capita with the rest of the population showed no difference in the three variables.

Micro-hydro projects – impact assessment

Running a two-sample *t*-test with an alpha level of 0.5 (skew < 2 and kurtosis < 8) and comparing the villages with small installed capacity per capita (N = 17) with those without a micro-hydro project (N = 67) we have identified no statistical significant difference between the two groups. A second set of *t*-tests, comparing villages with an installed capacity higher than 1 kW/capita of hydro (N = 8) with those which have no hydro power project developed (N = 67) also revealed no difference with respect to employment, revenues to the local budget and demographic variables.

Based on these results we can say that the installation of a micro-hydro power plant in North-Western Romania, contrary to expectations from the previous studies, has no impact on employment, revenues to the local budget or demographic of a specific village.

Wind power projects – impact assessment

Due to the small number of cases, combined with the consistent differences between the installed capacities we decided to compare each

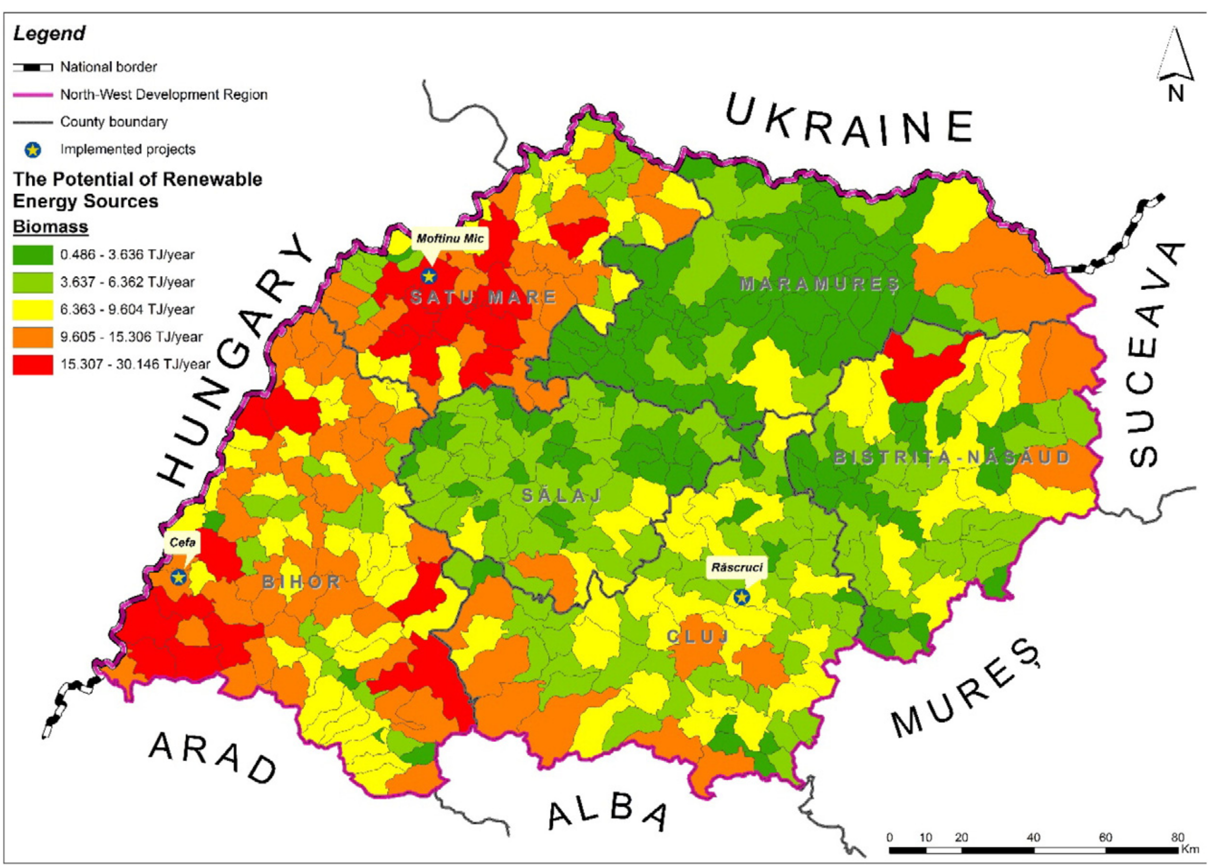

Fig. 14. Biomass energy potential and implemented projects in North-Western Romania.

Table 2
Values of population, employment and revenues to the local budget for communities with installed biomass power projects and with attest biomass power potential, 2014.

Township	Population	Employment	Revenues to the local budget (million)	Proportion of agriculture land used (Hectares)
Average case (locality without REP but with attested biomass potential)	3600 (st. deviation – 1870)	270 (st. deviation – 270)	1.4 (st. deviation – 1.1)	5880 (st. deviation – 2041)
Moftinu Mic	4536	383	2.1	8320
Rascruci	4826	214	4.0	7440
Cefa	2401	429	1.4	6113

village with an installed project with the total population of villages with attested wind potential. In order to see where the villages with developed wind projects will score in the general population distribution we computed a z-score for each of them on all three variables. A z-score specifies the precise location of each case in the distribution, and thus offers a perfect opportunity to observe whether any of the localities with operating wind power plants have a statistically significant different score from the general group of localities with attested wind potential. A z-score higher or lower than 2 would mean that our case is “noticeably different” from most of the individuals in the population (Gravetter and Wallnau, 2007).

Population means are normally distributed for all three variables (skew < 2 and kurtosis < 8). We will compare therefore the scores of each of the 5 villages against the population means on all three variables. As we can see from Table 1, none of the villages with installed wind power project had a z-score outside the ± 2 range. We can say that for the total population of villages that have attested wind potential, development of a wind power project does not lead to any statistically significant differences in terms of employment, revenues or population dynamics.

The same as for solar and hydro, the data for the wind power projects proves true our initial null hypothesis and finds no statistically significant relationship between the dynamics of employment, demographics or incomes to the local budgets and existence of a wind power project (Table 3).

Biomass power projects – impact assessment

Since our study focuses on the impact of renewable energy projects on the development of rural communities, we focus only on the 3 projects developed in villages Moftinul Mic (0.23 kW/capita), Cefa (1.24 kW/capita) and Rascruci (1.91 kW/capita).

The same as for the wind power projects, we rely on the z-scores to observe whether our two cases performed differently from the general population of villages with attested biomass potential. Compared to the previous three cases, for the biomass chapter we introduce also the forth variable – proportion of processed agriculture land. Population means on all four variables are normally distributed with skew < 2 and kurtosis < 8.

As we can see from in Table 4, computing z-scores on the researched variables for the two communities with implemented biomass projects revealed no significant differences between them and the general population with attested biomass potential. According to the available data we can say that all four null hypotheses are true for the biomass as well.

Contrary to the existing studies, all our null hypotheses were confirmed. Renewable energy projects in North-Western Romania do not have a sizable impact on revenues of the local communities, employment, demographics or proportion of agriculture land used. One possible explanation to this situation is the fact that while the biomass power plants could operate on the agriculture residuals, under the current legislation in Romania, the owners are encouraged to used energy intensive crops, such as Paulownia trees. Existing support scheme pays also a premium to the producers of energy intensive crops, in this way, the companies that have their own biomass power plants also invest in raising the primary material for it, neglecting in this way the agriculture residuals.

Discussion and conclusion

Comparing villages with deployed renewable energy projects with villages without such projects we found no statistical evidence to support the idea that a renewable energy project can have a positive impact on any of the four researched variables. The lack of any traceable impact of renewable energy projects on employment, revenues to the local budget, demographics or agriculture shows that their socioeconomic function has been widely overestimated, at least for the case of North-West Romania.

Given these findings, it is important to ask ourselves, why did renewable energy projects failed to produce the expected results? One possible answer is tied to the ownership structure of the projects. In the majority of cases REP projects are deployed by private investors, registered in urban centers. Under the current Romanian legislation, every renewable energy producer can qualify for government subsidies regardless of its origin or activity. Thus, while deployed in rural areas, projects are managed, both technically and financially from urban centers, which means that public budgets in these rural localities, as well as the local communities, have very little to gain from the REPs, as all the taxes paid by companies go to the urban and national budgets.

Furthermore, the existing support scheme, as well as energy legislation do not tie deployed REPs in any way to local communities. There is no obligation to sell the energy locally, to reinvest profits or to connect in any way with the host community. In this context, while the official statistics show those projects located in rural areas, it is only the land tax, which for rural areas is quite low, and the initial approval notice for building that really ties REPs to these communities.

Another possible reason behind the failure of the REPs to bring sustainable development is hidden in the nature of the projects themselves. Except the biomass projects, all the others are low maintenance projects that do not require local resources to operate them. Even in the construction and operation phases, companies prefer to bring skilled workforce from urban centers rather than invest in educating and training the locals. In this case, if we look at the number of jobs created per REP, we can argue that projects have an impact on employment, but if

Table 3
Distribution of wind installed capacity per capita and z-score for villages with developed wind power projects.

	z-Score on Del_Employment	z-Score on Del_Revenues	z-Score on Del_Population
Sannicoara (0.18 kW/capita)	−0.36	−0.88	−1.77
Borod (0.19 kW/capita)	−0.82	−0.07	−1.19
Piatra Fantanele (0.04 kW/capita)	−0.38	−0.92	−0.04
Tureni (0.12 kW/capita)	−0.59	0.38	−1.18
Tomnatic (2.42 kW/capita)	−0.71	0.51	−1.22

Table 4
Distribution of biomass installed capacity per capita and z-score for villages with developed biomass projects.

	z-Score on Del_Agric_Land (ha)	z-Score on Del_Employment	z-Score on Del_Revenues	z-Score on Del_Population
Moftinul Mic	−0.04	0.67	1.01	−0.36
Rascruci	−0.05	−0.46	1.22	−0.45
Cefa	0.09	1.63	−0.47	0.58

we connect these numbers with the residency of those employed we would find out that of the total number of employed persons only few, if any, are from the host community. Even in the rare cases when companies employ locals during the construction stage it is difficult to discuss about a real and sustainable employment effect since these employment contracts are rarely longer than 6 months. As for the biomass power plants, as we mentioned earlier, the owners are encouraged to produce their own energy crops rather than buying the agriculture residuals from the local farmers.

Certainly, the results of the present study are also exposed to a series of important limitations that we have to highlight. Firstly, it is the short time-span for our analysis. Looking at the period 2010–2014 cannot uncover the full effects of a renewable energy project and that is why further research on the data from 2016 and 2018 could be useful in order to see whether the implemented projects could have a delayed impact on the socio-economic indicators. Secondly, another shortcoming of this research are the variables scholars of energy policy are looking at. While employment, demographics and revenues are important variables to be considered when studying development, the possible impact of a REP can be much larger. REPs may have an impact on the innovative capacity of local communities, they can impact learning and technological transfer, community cohesion, public participation and environmental awareness. Unfortunately these variables are not yet widely considered, nor measured at the local level in connection to the deployment of a renewable energy project. In our opinion however, such measurements are both necessary and useful in order to understand the wider impact of the REPs.

Policy implications

As the data shows, for the case of Romania, classic economic indicators such as employment or income are not influenced by the deployment of a renewable energy project. While the investment in renewable energy projects is presented as a valuable source of development for the rural communities, in the current context, its impact seems to be quite low. Given that situation, we have to reconsider and adapt the existing policy approach toward REP support and promotion.

First and foremost, a national monitoring and evaluation system for renewable energy projects should be put in place in order to ensure access to the relevant data for the impact assessment of such investments on different dimensions, such as environment protection, energy efficiency objectives, local budgets, employment, other economic activities (such as agriculture) and local development, in general.

Based on this data, the existing support schemes have to be reshaped and the energy projects proposals should be evaluated on a sound cost-benefit analysis. The analysis should indicate not only the positive and negative externalities of each investment, but also the capacity of a renewable energy project to address different local needs such as environment protection, sustainable agriculture, employment and capacity building. Considering that Romania is in line with the 2020 strategy set by the European Commission, a clear cost-benefit analysis for each renewable energy project should be carried out. This analysis is needed in order to compare the environmental and socioeconomic benefits with the full range of short, medium and long-term costs.

Another important step to be made from a public policy perspective is the development of a sense of local ownership over renewable energy projects either by implementing public investments targeting local needs (access to energy, cost savings, employment), by supporting local entrepreneurship in this field, or by developing projects in the context of public-private partnerships. Once developed by the local communities the revenues from a renewable energy project will stay within the community, thus increasing the financial and non-finical gains within the community. Also it can lead to an innovative technical and financial behavior of communities who own a renewable energy project.

Innovation therefore should start playing a central role in designing and implementing renewable energy projects which have been largely standardized so far. Standardizing production of electricity can deprive the communities from the possibility to exploit locally the available energy resources and push them into a rigid, over-centralized national system, which at the end can turn out to be cost-inefficient. The impact on local economies can be boosted by facilitating technology transfer between different research and development initiatives providers (universities, research institutes, innovative start-ups and spin-offs) and public and private investors in renewable energy projects.

In conclusion, the impact of the renewable energy sector on development requires a closer consideration. Given the presented results it is important that we widen the scope of the current research and take a cautious stand regarding positive impacts of renewable energy projects. While renewable energy projects still represent a valuable resource to be exploited, both in terms of energy benefits as well as socioeconomic benefits, it requires a different policy approach. Fostering the development of community owned projects, better evaluation of prospect projects, re-shaping of the tax provisions, increasing the importance of innovative solutions to the integration of renewable energy projects within our society's activity are just few important changes required in order to exploit the full potential brought by the renewable energy sources.

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References

ADAS Consulting. Renewable energy and its impact on rural development and sustainability in the UK. Newcastle: ADAS Consulting for University of Newcastle; 2003.
Bolton RPG, Foxon TJ. Infrastructure transformation as a socio-technical process — implications for the governance of energy distribution networks in the UK. Technol Forecast Soc Chang 2014;90:538–50.
Buchan D. The Energiewende - Germany's gamble. Oxf. Inst. Energy Stud., 26; 2012. p. 1–23.
Cristea M. Aplicatii ale teoriilor si conceptului de pol de crestere in Romania. Babes-Bolyai University; 2013.
del Rio P, Burguillo M. Assessing the impact of renewable energy deployment on local sustainability: towards a theoretical framework. Renew Sustain Energy Rev 2008;12:1325–44.
del Rio P, Burguillo M. An empirical analysis of the impact of renewable energy deployment on local sustainability. Renew Sustain Energy Rev 2009;13:1314–25.
Destouni G, Frank H. Renewable energy. Ambio 2010;39:18–21.

Dincer I. Renewable energy and sustainable development: a crucial review. Renew Sustain Energy Rev 2000;4:157–75.
Dulcinea Cuellar A. Plant power: the cost of using biomass for power generation and potential for decreased greenhouse gas emissions [PhD] The University of Texas at Austin; 2009.
Emmanouilides CJ, Sgouromalli T. Renewable energy sources in Crete: economic valuation results from a stated choice experiment. Procedia Technol 2013;8:406–15.
Eurostat Newsletter. Renewable energy in the EU; 2016.
Faulin J, Lera-López F, Arizkun A, Pintor JM. Energy policy in renewables and its economic and environmental consequences at regional level: the case of Navarre (Spain). Energy Policy 2009:1–57.
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Bruttobeschäftigung durch erneuerbare Energien in Deutschland im Jahr 2008. Berlin: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; 2009a.
Goldthau A. Rethinking the governance of energy infrastructure: scale, decentralization and polycentrism. Energy Res Soc Sci 2014;1:134–40.
Gravetter FJ, Wallnau LB. Statistics for the behavioral sciences. Canada: Vicki Knight; 2007.
Hanley N, Nevin C. Appraising renewable energy developments in remote communities: the case of the North Assynt Estate, Scotland. Energy Policy 1999;27:527–47.
IRENA. Biomass for power generation. Bonn, Germany: International Renewable Energy Agency; 2012.
Kammen DM, Kapadia K, Fripp M. Putting renewables to work: how many jobs can the clean energy industry generate? Berkeley: University of California; 2004.
Kohr RL, Games PA. Robustness of the analysis of vairance, the Welch procedure and a box procedure to heterogeneous variances. J Exp Educ 1974;43:61–9.
Lang T. Shrinkage, metropolization and peripherization in East Germany. Eur Plan Stud 2010;1747–1754.
Legea 220 din 27/10/2008, 2008.
Markard J. Transformation of infrastructures: sector characteristics and implications for fundamental change. J Infrastruct Syst 2011;17:107–17.
Ministerul Economiei. Studiu privind evaluarea potentialului energetic actual al surselor regenerabile de energie in Romania (solar, vant, biomasa, microhidro, geotermie). Identificarea celor mai bune locatii pentru dezzvoltarea investitiilor in producerea de energie electrica neconventionala. Bucuresti: Ministry of Economy, Romania; 2008.
OECD. Linking renewable energy to rural development (OECD); 2012.
Quaschning V. Understanding renewable energy systems. London, Sterling: Earthscan; 2005.
Transelectrica. Contracte de Racordare. Transelectrica; 2015.